

630.7

I l 6b

no.624

cop.8

UNIVERSITY OF
ILLINOIS LIBRARY
AT URBANA-CHAMPAIGN

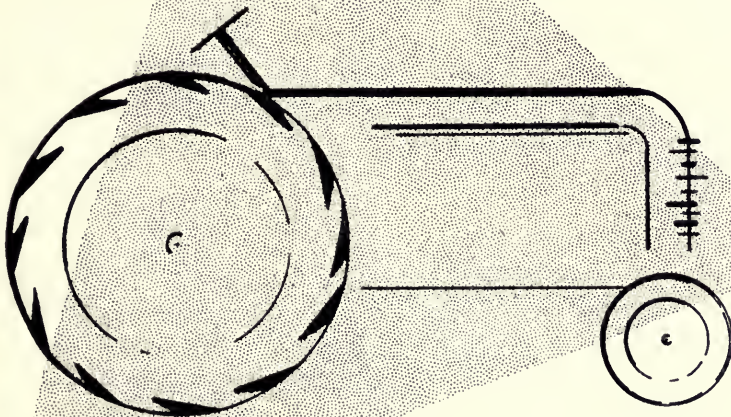
~~BOOKS~~

630.7
IL66
no. 624
Cap 18

CIRCULATING COPY
AGRICULTURE LIBRARY

MAINTENANCE INSPECTIONS OF SIXTY FARM TRACTORS

by J. A. Weber



BULLETIN 624

AGRICULTURE LIBRARY

JAN 23 1990

**UNIVERSITY OF ILLINOIS • AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF ILLINOIS**

CONTENTS

PROCEDURE 3 TRACTOR INSPECTIONS 4 Method of Scoring..... 4 Condition and Grouping of Items..... 6 TRACTOR REPAIRS 8 QUESTIONING OF THE TRACTOR OPERATOR 10 COMPARISON OF MANUAL RECOM- MENDATIONS AND OPERATORS' ACTUAL PRACTICES 13 MAINTENANCE OF INDIVIDUAL ITEMS..16 Governor Adjustment 16 Crankcase Oil Condition.....17 Oil Type and Viscosity.....18 Brake Adjustment 19 Tire Pressure 19 Ignition Point Condition.....21 Battery-Liquid Level 21 Carburetor Float Level.....22	Air Cleaner Service.....23 Valve Clearances 24 Crankcase Breathers 26 Transmission Oil Change.....26 OPERATORS' MANUALS AND TRACTOR DESIGN 29 RECOMMENDATIONS 33 Standardizing Maintenance Intervals.33 Making Recommendations Realistic...33 Improving Instruction Manuals.....33 Fastening Metal Reminders on Tractors 34 Improving Communication Between Farmers and Manufacturers....34 SUMMARY 36 APPENDIX 37 Summary of Tractor Inspections.....37 Summary of Operators' Answers to Personal Interview.....40 LITERATURE CITED 44
---	---

ACKNOWLEDGMENTS

This study covers one phase of a project on improvement of tractor maintenance sponsored by the Illinois Farm Supply Company, which is providing part of the financial support and the services of the laboratories of its Petroleum Division. A number of petroleum and machinery companies also gave valuable assistance in planning the tractor inspections and establishing methods of evaluation.

Especial acknowledgment is made to senior mechanic Roy Brockett, whose careful tractor inspections and pleasant personal relations with the operators contributed greatly to the success of this study.

Ultimately, of course, this report was dependent upon the cooperative spirit of the 60 farmers who made their tractors available and were tolerant in answering the many interview questions.

MAINTENANCE INSPECTIONS OF SIXTY FARM TRACTORS

By J. A. WEBER, Assistant Professor of Agricultural Engineering

FARM MACHINES are powered by millions of tractors. To farm efficiently, owners must keep their tractors operating at peak performance and extend the life of tractor parts. This goal can be accomplished through proper tractor care and maintenance.

Although bus and truck fleets are held to strict maintenance schedules, and even the private automobile is usually cared for by a service station attendant, the maintenance chores on the farm tractor must be performed by the owner or operator himself. Each owner must be made aware of the maintenance chores on his tractor and must be motivated to complete them, even though other farm activities and responsibilities may be demanding his time and attention.

Several previous studies have shown the importance of performing these chores. Bateman and Weber tested 18 tractors "as found," and again after simple repair and adjustment. They reported an average increase of 16 percent in maximum power and 19 percent in efficiency as a result of performing maintenance chores (2)*. In a later study at the University of Nebraska, Smith and Larsen showed an average gain of 8 percent in power and 10 percent in efficiency (5).

This report deals with the problem of obtaining better tractor maintenance on the farm. The 60 tractors in this study were inspected for evidence of good or poor maintenance practices rather than horsepower and efficiency. The condition of the tractor was then correlated with the operator's actual practices and his knowledge of manual recommendations.

The condition of individual parts and interviews with the operators indicated several possible methods for improving tractor care, increasing operating efficiency, and extending the life of tractor parts.

PROCEDURE

The tractors included in this study were privately owned by farmers of Champaign county and surrounding counties. To qualify for inspection, a tractor had to be one of ten specified models and at least two years old. A minimum of two years of ownership was considered

* Numbers in parentheses refer to the literature citations on page 44.

necessary in order for the inspection to reveal the operator's maintenance habits.

The Shell ADC Spot Test (1) was used to check oil condition; viscosity was checked by comparing the sample from the crankcase with known standards in the falling ball test. Engine timing was checked with a neon light. The degree of air cleaner restriction was measured by inserting a hypodermic needle in the air cleaner hose and measuring the air cleaner vacuum with a water manometer.

During the tractor inspection, the operator was personally interviewed on three phases of tractor care: 1, his knowledge of the tractor manual recommendations; 2, his actual practice; and 3, his opinion as to what should be done. Operators were encouraged to answer as many questions as possible and to guess at the manual recommendation if they were uncertain of the answer.

The tractor inspection and operator interview covered all items of "on the farm" maintenance. A list of the parts included in the inspections and the items covered in the questionnaire is given in the Appendix.

For ease in tabulating results, information from both the inspection and questionnaire data sheets was placed on IBM punch cards. Analysis of variance procedures were used to determine significant differences in inspection results and life of tractor parts.

TRACTOR INSPECTIONS

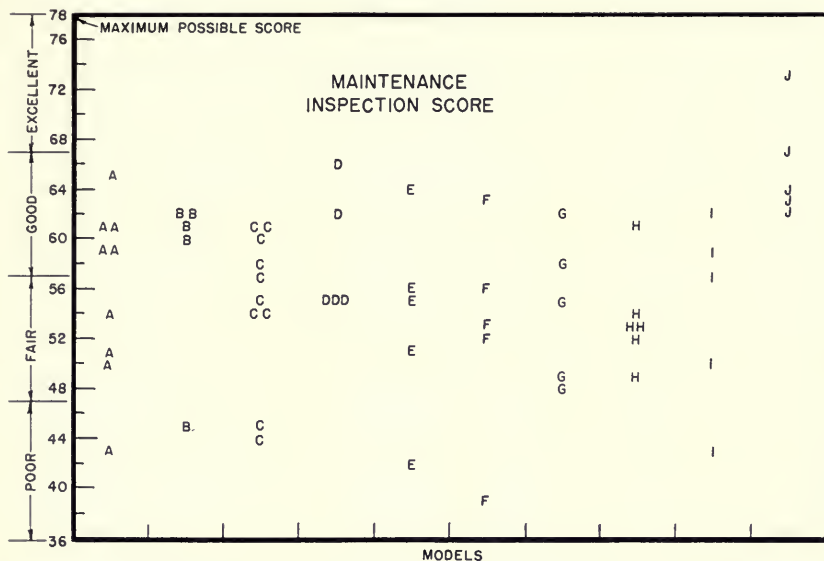
Sixty tractors, representing ten models of eight different makes, were inspected in the summer and fall of 1955. Five of the tractors were Diesels and five were operated on liquefied petroleum gas. In this report, the models will be designated by letters A through J. The inspection included 9 tractors of model A, 10 of model C, 6 of model H, and 5 tractors each of the remaining seven models.

The number of tractors of each model inspected approximates the proportionate number of that model owned by farmers in Champaign county and adjoining areas.

METHOD OF SCORING

Seventy-eight points or items were included in the tractor inspections. A tractor in perfect condition received a maintenance score of 78. The score was reduced by the number of maintenance deficiencies. For example, if ten items on a tractor showed lack of care, the maintenance score for that particular tractor was 68.

Each tractor included in the inspection, with its respective maintenance score, is shown in Fig. 1. The ages of the operators ranged from 25 to 70 years, and no correlation existed between the operator's age and tractor condition.



Although scores often varied considerably for tractors of the same model, all of the tractors inspected had maintenance deficiencies. (Fig. 1)

One model J tractor had the highest individual score (73 points), and all the tractors of model J had scores well above average. In interpreting these scores it should be remembered that model J was a Diesel, and the manual did not require operator service of its compression ignition system. For this reason, model J automatically scored high on the condition of its ignition system. The spark ignition systems of the gasoline and LP gas tractors, on the other hand, were graded down if they were in poor condition.

A model F tractor had the lowest score of all tractors inspected. Model F is operated primarily as a second or odd-job tractor in this area, and the odd-job tractor is often poorly cared for because it is used for jobs that do not demand peak power and efficiency. It is also difficult for operators to remember the maintenance intervals for tractors used on very irregular schedules.

CONDITION AND GROUPING OF ITEMS

For the inspection, the condition of individual items was either judged "o.k." or classified as having some degree of deficiency. For example, the battery liquid level was classified as "o.k.," "high," "low," or "below the plates." To compare the condition of all items inspected, each item was placed in one of three categories: in good condition; needed attention but getting by; and needed immediate attention.

After all tractors had been inspected, the items were divided into three groups (Fig. 2). The grouping of the items was based upon the number of tractors with a deficiency and the importance of the item to tractor performance, life of parts, and operator safety.

Group I:

The items listed in Group I were either in good condition, or if not in good condition, did not seriously affect the performance of the tractor or the safety of the operator.

For example, the PTO clutch adjustment was in good condition on 100 percent of the 57 tractors inspected. Battery charge, on the other hand, was satisfactory on only 79 percent of the 48 tractors inspected; it needed attention on 13 percent and immediate attention on 8 percent of the tractors. Since low battery charge is not critical to operation, however, this item also appears in Group I. Only a few of the items in Group I were in need of immediate service.

Group II:

The items listed in Group II could have been better cared for, but their poor condition was not a critical matter. For example, the rear axle splines on 34 of 46 tractors were rusty. This condition might make it difficult to adjust rear wheel width, but it would not affect operation in the field. Crankcase oil levels were low on several tractors, but the operators indicated that the oil levels would have been checked and oil added before the tractors started another full day of operation.

Group III:

The items in Group III were the critical maintenance items for these 60 tractors and definitely should have received better care. With a few exceptions, the deficiencies listed were found on all makes and models. (Poor governor adjustment was found on only two models; one model required no crankcase breather service; and, of course, Diesel engines had no spark ignition system deficiencies.)

The proper care of the items in Group III concerns all farmers, agriculture extension workers, and the entire tractor industry. The condition of these items and the probable reasons for their neglect will be discussed in detail later in this report.

ITEMS INSPECTED	IN GOOD CONDITION	NEEDED ATTEN- TION BUT GETTING BY			NEEDED IMMED- IATE ATTENTION			NO. OF TRAC- TORS		
	PERCENT OF TRACTORS INSPECTED									
GROUP I	25	50	75	25	50	75	25	50	75	
PTO CLUTCH - ADJUSTMENT										57
WATER TEMPERATURE - GAGE										52
SPARK PLUGS - RANGE										55
GENERATOR AND REGULATOR										60
RADIATOR PRESSURE CAP										60
POWER LIFT-HOSES AND GASKETS										56
FRONT WHEEL BEARING - LUBR.										52
OIL PRESSURE AND GAGE										60
SPARK PLUGS-DEPOSITS										55
SPARK PLUG WIRES										55
SPARK PLUGS - CONDITION										55
REAR TIRES - CONDITION										60
CARBURETOR-MAIN JET-ADJUSTMENT										49
STARTER-OPERATION										60
AIR CLEANER HOSE										50
DISTRIBUTOR CAP										50
RADIATOR SCREEN										45
CLUTCH - ADJUSTMENT										60
BATTERY -CHARGE										48
ENGINE-TIMING										54
GROUP II										
FUEL LINES										60
RADIATOR WATER-LEVEL										60
RADIATOR HOSES										60
AIR PRECLEANER-SERVICE										59
TRANSMISSION OIL-LEVEL										60
FRONT WHEEL BEARINGS-ADJMT.										57
FRONT TIRES-CONDITION										60
AIR CLEANER-LEVEL										59
CARBURETOR IDLE-ADJUSTMENT										50
BREAKER CAM-CONDITION										48
FAN BELT-TENSION										55
CRANKCASE OIL-LEVEL										59
POWER LIFT OIL-LEVEL										50
STEERING GEAR-ADJUSTMENT										60
BATTERY-CLEANLINESS										60
RADIATOR FINS-CLEANLINESS										60
SPARK PLUGS-GAP										55
TRACTOR-CLEANLINESS										60
REAR AXLE SPLINE-CONDITION										46
SEDIMENT BOWL-SERVICE										47
GROUP III										
GOVERNOR-ADJUSTMENT										60
CRANKCASE OIL-CONDITION										59
BRAKES-ADJUSTMENT										60
REAR TIRES-PRESSURE										60
IGNITION POINTS-GAP										47
BATTERY-LIQUID LEVEL										60
CARBURETOR FLOAT-LEVEL										50
AIR CLEANER BODY-SERVICE										58
IGNITION POINTS-CONDITION										50
EXHAUST VALVES-CLEARANCE										55
INTAKE VALVES-CLEARANCE										55
FRONT TIRES-PRESSURE										60
AIR CLEANER CUP-SERVICE										60
CRANKCASE BREATHER-SERVICE										54

The condition of all items inspected needed improvement, but the items listed in Group III are critical to tractor operation and should be considered first in a maintenance improvement program. (Fig. 2)

TRACTOR REPAIRS

Operators of the 60 tractors were asked to look up in their records or attempt to recall the type and number of repairs that had been made to their tractors.

The average frequency of repairs or replacements of various tractor parts is shown in Table 1. The first column shows the number of tractors with one or more repairs or replacements of a given item. For example, 53 tractor owners reported one or more spark plug set replacements, and the average plug life on these 53 tractors was 1.3 years.

Many of the expensive tractor parts, such as rings, pistons and sleeves, tires, etc., have an average life of four to five years; and as previous studies have shown, the tractor owner usually can expect a large repair bill during the fourth or fifth year of operation.

Analysis of variance was used to determine the differences between models in the life of parts. Those parts for which a significant differ-

Table 1. — Life of Parts of 60 Farm Tractors

Items	Number of tractors	Years between repairs		
		Average interval	Shortest individual interval	Longest individual interval
Spark plugs, replaced.....	53	1.3	.5	6
Battery, replaced.....	50	2.8	1	5
Valves, overhauled.....	35	3.2	1	8
Fan belt, replaced.....	34	2.5	1	7
Magneto or distributor, repaired...	24	2.8	.7	7
Pistons and sleeves, replaced.....	24	4.7	1	8*
Piston rings, replaced.....	24	4.1	1	8*
Front tire, replaced.....	22	4.5	2	8*
Rear tire, replaced.....	20	4.6	3	8
Generator, repaired.....	17	3.6	1	8*
Brake lining, replaced.....	17	5.4	2	8*
Governor, repaired.....	12	6.0	4	9*
Clutch, relined.....	12	3.9	2	5*
Carburetor, repaired.....	10	4.0	2	6*
Hydraulic systems, repaired.....	9	4.2	1	7*
Steering gear, repaired.....	8	4.6	3	7*
Front wheel bearing, repaired.....	7	5.5	3	9*
Transmission, overhauled.....	5	5.4	3	7*
Water pump, replaced.....	2	2.0	2	2*
Starter, repaired.....	2	4.5	2	7*

* This item had not been repaired on some tractors 10 years old at the time of inspection. The average age of all tractors inspected was 5.7 years.

ence in life was found between tractor models are listed in Table 2. Because of the small number of tractors involved in this study, it could not be determined if there was a significant difference between models in the life of the other parts in Table 1.

Only the models with the shortest and longest intervals between replacements or repairs are listed in Table 2. For example, the average life of spark plugs was shortest (0.9 year) in Model A and longest (4 years) in Model I, an LP gas tractor.

Table 2. — Life of Parts That Differed Significantly Between Tractor Models

Item	Average for all tractors	Years between repairs			
		Shortest interval		Longest interval	
		Tractor model	Average interval	Tractor model	Average interval
Spark plugs, replaced.	1.3	A	.9	I ^a	4.0
Battery, replaced (original only)	3.4	A	2.8	C	3.9
Battery, replaced (all)	2.8	A, E, F	2.3	C	3.1
Valves (first overhaul only)	3.9	B	1.8	E	5.5
Valves (all overhauls)	3.2	B	1.7	E	4.6
Piston rings, replaced	4.1	B	2.5	I	(not needed) ^b
Piston and sleeves, replaced	4.7	A	4.0	I	(not needed) ^b
Fan belt, replaced	2.5	A	2.3	C	3.2

^a Model I is an LP gas tractor.

^b No overhauls in an average of 6 years of operation.

Although plug life varied significantly between gasoline and LP gas tractors, there was little variation among gasoline tractors. Gasoline tractors varied widely, however, in life of both original and replacement batteries. In valve life, Model B differed considerably from other models. In piston rings and pistons and sleeves, as in plug life, the significant difference was between gasoline and LP gas tractors rather than among the gasoline models. Fan belt life varied from 2.3 years for Model A to 3.2 years for Model C.

The life of some tractor parts apparently varies more from model to model than between tractors of the same model. But by sound maintenance practices, the farmer can extend the life of the parts of his tractor to exceed the average for his particular model.

QUESTIONING OF THE TRACTOR OPERATOR

Each of the 60 tractor operators was interviewed on three aspects of tractor maintenance:

1. His actual maintenance practice for each item on his tractor.
2. His knowledge of the frequency of service recommended by the manual.
3. His opinion as to the amount of service each item should receive.

Operators were asked to describe their own practice during the busy season when the tractor was used every day, and to answer as many questions as possible about the manual recommendations (even guessing if they were not sure).

Practically all of the operators gave definite answers about their actual practices, but several did not answer the questions on manual recommendations.

Although all 60 operators were asked to answer all of the questions, only those operators whose manuals had a specific recommendation are included in the analysis in Tables 3, 4, and 5. For example, since only 25 of the 60 operators had manuals with a recommended interval for inspection of distributor points, only the answers of these 25 operators are included in the three tables.

The operators' answers were compared with manual recommendations. Since the recommended interval of service varied from item to item, and from tractor to tractor for the same item, the comparison with manual recommendations could not be summarized until the answers were placed in five classifications:

1. The answer agreed with the manual recommendation.
2. The interval of service given in the answer disagreed as much as 100 percent from the manual recommendation. For example, if the recommendation was once a week and the answer was once every two weeks, it would appear in this classification.
3. The answer disagreed with the recommended interval by more than 100 percent.
4. The operator said that the item was never serviced.
5. The operator did not answer the question, or his answer could not be classified.

Table 3. — Operators' Actual Practices Related to Manual Recommendations as to Frequency of Service

Items (Listed in order of operators' compliance with manual recommendations)	Number of operators	Percent of operators questioned				
		Followed manual recommen- dations	Off 100% or less in interval	Off more than 100% in interval	Never serviced item	Did not answer
Group X ^a						
Engine oil level check.....	60	60	38	2	..	..
Engine oil filter change.....	60	55	33	12	..	..
Battery level check.....	55	54	13	33	..	..
Radiator level check.....	60	53	13	34	..	..
Distributor point check.....	25	52	4	32	12	..
Water pump or fan lubrication.....	50	50	2	28	..	20
Grease fittings, steering, etc.....	60	47	22	32	..	..
Grease fittings, rear axle.....	60	45	18	29	..	8
Generator lubrication.....	60	38	32	22	..	8
Steering gear oil level.....	45	38	11	24	..	..
Valve clearance check.....	36	33	6	30	25	6
Engine oil change.....	60	32	55	10	..	3
Spark plug inspection.....	34	29	18	32	21	..
Radiator flush.....	41	29	42	12	15	2
Group Y						
Hydraulic system oil change.....	55	24	9	2	51	14
Air cleaner oil change.....	60	18	27	55	..	..
Air cleaner cup check.....	60	15	37	48	..	..
Front wheel lubrication.....	60	15	30	43	12	..
Steering gear oil change.....	41	15	..	..	61	24
Clutch lubrication.....	40	13	15	50	..	22
Crankcase breather service.....	48	13	2	50	35	..
Starter lubrication.....	30	13	15	50	..	3
Distributor lubrication.....	40	10	10	22	43	15
Air cleaner, complete cleaning.....	60	7	8	27	58	..
Transmission oil change.....	60	7	7	20	64	2
Clutch adjustment.....	25	4	4	72	20	..
Tire pressure check.....	41	2	2	96	..	..
Brake adjustment.....	20	..	10	80	5	5

^a Group X lists the items for which the operators were following manual recommendations fairly well; Group Y lists the items for which the operators were not following manual recommendations satisfactorily.

Table 4. — Operators' Knowledge of Frequency of Service Required by Manual Recommendations

Items (Listed in order of operators' compliance with manual recommendations)	Number of operators	Percent of operators questioned				Thought item re- quired no service	Did not answer
		Knew recommen- dation exactly	Off 100% or less in interval	Off more than 100% in interval			
Group X ^a							
Engine oil level check.....	60	55	17	..	..	28	
Engine oil filter change.....	60	37	13	8	..	42	
Battery level check.....	55	24	4	16	..	56	
Radiator level check.....	60	50	8	..	..	42	
Distributor point check.....	25	16	8	..	..	76	
Water pump or fan lubrication.....	50	34	..	12	..	54	
Grease fittings, steering, etc.....	60	38	7	13	..	42	
Grease fittings, rear axle.....	60	28	17	12	..	43	
Generator lubrication.....	60	27	12	10	..	31	
Steering gear oil level.....	45	16	13	13	..	58	
Valve clearance check.....	36	3	19	..	..	78	
Engine oil change.....	60	32	35	5	..	28	
Spark plug inspection.....	34	9	12	6	3	70	
Radiator flush.....	41	12	22	17	..	49	
Group Y							
Hydraulic system oil change.....	55	20	13	..	..	67	
Air cleaner oil change.....	60	45	5	12	..	38	
Air cleaner cup check.....	60	65	3	5	..	27	
Front wheel lubrication.....	60	17	25	17	..	41	
Steering gear oil change.....	41	8	..	..	8	84	
Clutch lubrication.....	40	15	5	22	..	58	
Crankcase breather service.....	48	15	2	13	..	70	
Starter lubrication.....	30	0	13	23	..	64	
Distributor lubrication.....	40	5	8	3	3	81	
Air cleaner, complete cleaning.....	60	3	12	13	3	59	
Transmission oil change.....	60	40	15	3	5	37	
Clutch adjustment.....	25	4	8	8	..	80	
Tire pressure check.....	41	5	2	12	..	81	
Brake adjustment.....	20	5	..	..	..	95	

^a Group X lists the items for which the operators were following manual recommendations fairly well; Group Y lists the items for which the operators were not following manual recommendations satisfactorily.

COMPARISON OF MANUAL RECOMMENDATIONS AND OPERATORS' ACTUAL PRACTICES

In Table 3 the maintenance items are listed according to the percentage of operators who were following the manual recommendation. For example, practically all of the operators were either checking engine oil level according to manual recommendations or at intervals less than 100 percent from manual recommendations. By contrast, most operators checked tire pressure and brake adjustment at intervals varying more than 100 percent from manual recommendations.

For convenience in discussing these maintenance items, they are divided into two groups — X and Y. Operators were doing a fairly good job of following manual recommendations for the items in Group X, but not for the items in Group Y.

There was no apparent correlation between the condition of an item and the operator's compliance with the manual recommendation. For example, operators complied closely with recommendations for battery level check, distributor points inspection, and engine oil change (listed in Group X). Nevertheless, the battery level, points, and engine oil were often unsatisfactory. Other critical maintenance items in poor condition — air cleaner, crankcase breather, tire pressure, and brake adjustment — appear in Group Y.

More than 50 percent of the operators having manuals with specific recommendations never change oil in the steering gear, transmission, or power lift, or completely clean the air cleaner. Between 25 and 50 percent never check check valve clearances, lubricate the distributor, or service the crankcase breather.

OPERATORS' KNOWLEDGE OF MANUAL RECOMMENDATIONS

The operators' knowledge of the manuals is shown in Table 4. The maintenance items are listed in the same order as in Table 3; that is, in order of the percentage of farmers who were actually following manual recommendations. Again, the number of operators who owned manuals with specific recommendations is given in the column headed "number of operators." Those operators who did not volunteer an answer as to what the manual recommended are listed in the "did not answer" column under "percent of operators questioned."

Sixteen farmers (27 percent of the 60 operators interviewed) did not believe that they knew any of the manual recommendations and would not attempt to answer this part of the questionnaire; yet all of these operators were following some type of recommendation in their

Table 5. — Operators' Opinions Related to Manual Recommendations as to Frequency of Service

Items (Listed in order of operators' compliance with manual recommendations)	Number of operators	Percent of operators questioned				Thought item re- quired no service	Did not answer
		Agreed with manual recommen- dations	Off 100% or less in interval	Off more than 100% in interval			
Group X ^a							
Engine oil level check.....	60	58	37	2	..	3	3
Engine oil filter change.....	60	55	25	17	..	3	3
Battery level check.....	55	43	16	41	..	..	..
Radiator level check.....	60	52	22	26	..	32	..
Distributor point check.....	25	36	20	12	..	..	..
Water pump or fan lubrication.....	50	40	6	18	..	36	..
Grease fittings, steering.....	60	47	23	27	..	3	3
Grease fittings, rear axle.....	60	44	18	25	..	13	..
Generator lubrication.....	60	38	35	20	..	7	..
Steering gear oil level.....	45	34	13	24	7	22	..
Valve clearance check.....	36	22	30	17	6	25	..
Engine oil change.....	60	29	54	7	..	10	..
Spark plug inspection.....	34	41	29	14	..	26	..
Radiator flush.....	41	29	44	7	5	15	..
Group Y							
Hydraulic system oil change.....	55	24	15	..	20	41	..
Air cleaner oil change.....	60	23	27	47	..	3	..
Air cleaner cup check.....	60	25	28	40	..	7	..
Front wheel lubrication.....	60	13	40	36	3	8	..
Steering gear oil change.....	41	15	2	..	59	24	..
Clutch lubrication.....	40	15	15	43	..	27	..
Crankcase breather service.....	48	25	2	63	2	8	..
Starter lubrication.....	30	32	12	37	..	39	..
Distributor lubrication.....	40	15	17	12	8	48	..
Air cleaner, complete cleaning.....	60	25	3	35	17	20	..
Transmission oil change.....	60	15	12	17	30	27	..
Clutch adjustment.....	25	..	8	72	8	12	..
Tire pressure check.....	41	7	5	68	..	20	..
Brake adjustment.....	20	..	10	60	30	..	..

^a Group X lists the items for which the operators were following manual recommendations fairly well; Group Y lists the items for which the operators were not following manual recommendations satisfactorily.

actual practice. They mentioned magazine articles, extension meetings, dealers, mechanics, and neighbors as sources of information about tractor maintenance. Some of the operators were following the same procedures they had used on previously owned tractors.

The "did not answer" column in Table 4 gives an indication of the operators' knowledge of the manual recommendations for these maintenance items. Since all but 16 men answered the question as to how often the air cleaner should be checked, most operators apparently had some idea of what the manual recommendation might be for this item. On the other hand, 70 percent of the operators would not even guess at the manual recommendation for crankcase breather service.

Items in Group Y for which operator education was comparatively good but compliance poor include air cleaner oil change, air cleaner cup check, and transmission oil change. Although many items appear in the "never serviced" column in Table 3, practically all of the operators knew that the manual required service of these items.

OPERATORS' OPINION AS TO FREQUENCY OF SERVICE

Operators were also asked how frequently they thought each of these items should be serviced (Table 5). Their answers did not necessarily agree with either the manual recommendations or their actual practices.

Since more operators answered this part of the questionnaire, there are fewer numbers in the "did not answer" column in Table 5. Over 40 percent of these men had no opinion as to how often the power lift oil should be changed or how often the distributor should be greased on their tractors.

The items in Table 5 are again listed in order of degree of compliance with manual recommendations. In general, operators' opinion agreed fairly well with their actual practice. This fact indicates that operators acted upon their opinions rather than blindly following recommendations, and emphasizes the importance of including "why" in manual recommendations.

The operators' opinions were more nearly in accordance with manual recommendations than their actual practice on spark plug check, air cleaner and crankcase breather service, starter lubrication, and transmission oil change (see Tables 3 and 5). Many of the operators who had never performed some of the maintenance chores thought that they should be performed. For example, more than one-half of the operators who had not changed transmission or hydraulic system oil believed that the oil should be changed.

MAINTENANCE OF INDIVIDUAL ITEMS

To discuss improved maintenance of the items listed in Group III, Fig. 2, it is necessary to consider the following points:

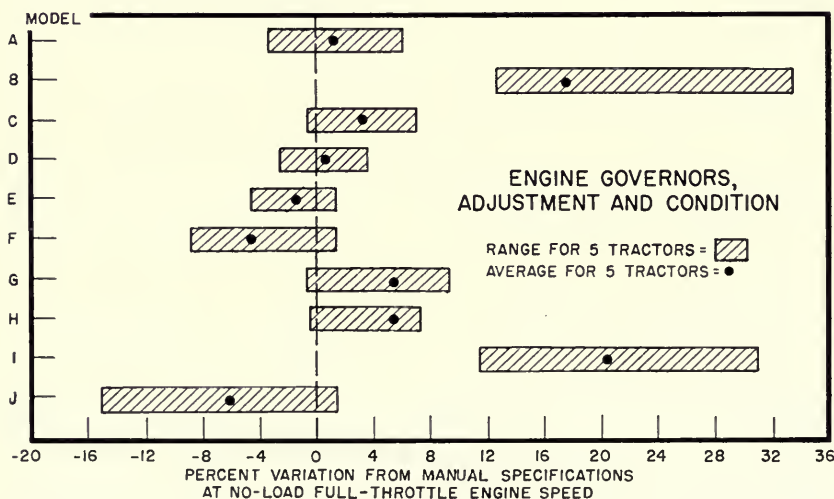
1. the practicability of the manual recommendation
2. the time and effort necessary to service the item
3. the operator's knowledge of the manual recommendation
4. his opinion as to how often the item should be serviced
5. his actual practice in servicing it
6. the condition of the item

GOVERNOR ADJUSTMENT

Governor adjustment was checked by recording the full-throttle no-load engine speed and comparing it with the specified speed in the owner's manual. The ranges of speed for five tractors of each model are shown in Fig. 3.

All ten engines of models B and I were running more than 12 percent too fast, and engines of tractor model J were running too slow. The governor adjustment on models B, I, and J was on the outside of the engine where it could easily be changed by the operator.

On tractor models C, D, and E the governor adjustment was inside the engine, and the governor housing was sealed to prevent adjustment



Models B and I were running more than 12 percent too fast. Since the adjustment on these two models was outside the engine, it may have been changed by the operators. (Fig. 3)

by anyone other than a mechanic. The speeds of these 15 engines varied less than 7 percent from the specified no-load speed.

Since many farmers do not have revolution counters and are not aware of the effects of excessive engine speeds, the governor adjustment should be enclosed and sealed against tampering. Only qualified mechanics should adjust the governor, and dealers should be encouraged to include a check of governor adjustment as a part of tractor tuneup.

CRANKCASE OIL CONDITION

Twenty-four of the 60 tractors needed a crankcase oil change. The Shell ADC spot test (1) and a microscope were used to determine the condition of crankcase samples. Oil was classified as needing a change for one or more of the following reasons:

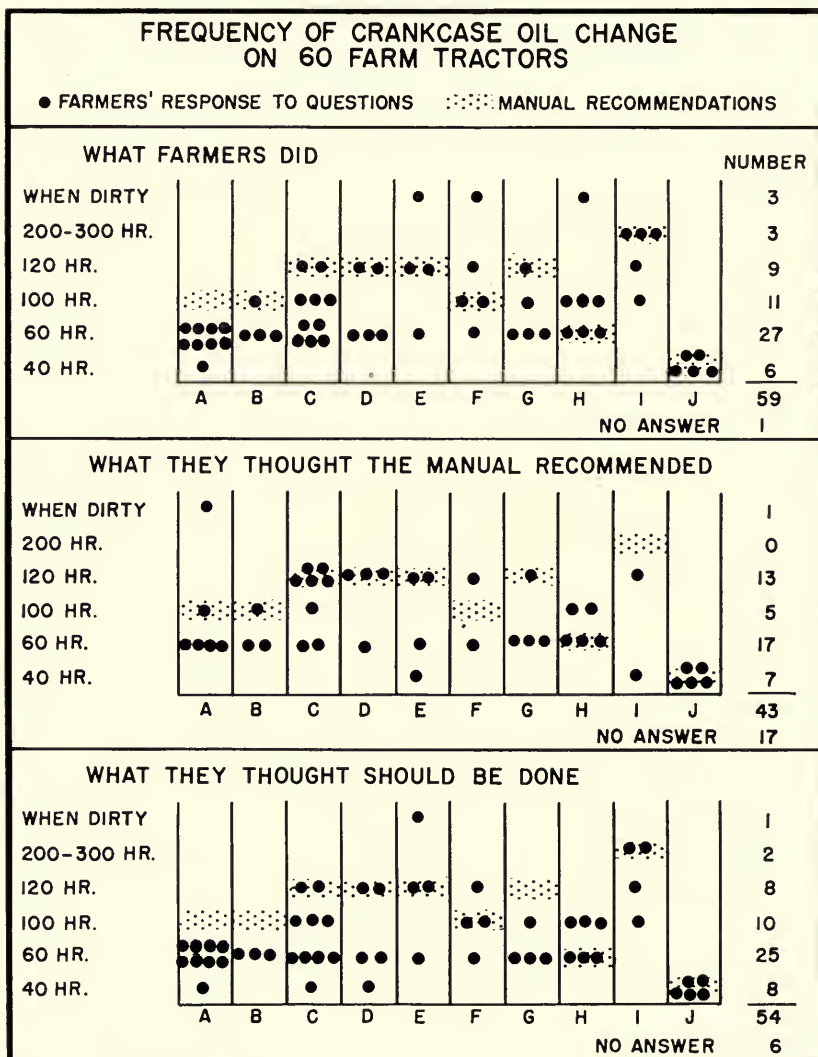
1. Oil was carrying a heavy dirt load (8 tractors).
2. Oil was inadequately dispersing its load of dirt (3 tractors).
3. Microscopic examination showed particles of silica (11 tractors).
4. Oil was acid by the ADC test (14 tractors).

Among these 60 tractors, there was no recognizable relationship between oil acidity and brand or type of oil, model of tractor, hours of use, or condition of the crankcase breather at the time of inspection. Two of the 14 oil samples that were acid had less than 20 hours of use.

Twenty-one of 59 operators were changing oil according to manual recommendations (Fig. 4). Thirty-one operators were changing oil oftener than recommended, many of them at 60-hour intervals. Some of these operators had previously owned tractors for which an oil change was recommended every 60 hours, and they continued to follow this recommendation regardless of whether it agreed with the manual recommendation for their new tractors.

A comparatively large number of operators — 43 — volunteered an answer on the frequency of oil change recommended by the manual. However, 14 of these operators thought the manual recommended 60 hours instead of the actual recommended interval of 100 or 120 hours. Figure 4 shows that their opinion of what should be done differed little from their actual practice.

Although these operators said they were changing oil as often or oftener than recommended, the ADC test showed 24 samples in need of change. The change in oil condition as related to maintenance and operating practices should be studied more intensively.



Most operators were changing crankcase oil at 60-hour intervals. This interval was considered standard for a number of years, and operators continued to follow it regardless of the actual recommendations for their tractors. (Fig. 4)

OIL TYPE AND VISCOSITY

Operators were not familiar with API oil service classifications such as MS and DG, and were not sure of the viscosity of oil required by their tractors. Most operators depended on their petroleum salesman to supply them with oil of the proper classification and viscosity.

Forty-three of the tractors had oil of the correct viscosity. Ten tractors had oil that was one viscosity number too heavy, and three were using oil that was one number light. Although one-half of the operators did not correctly identify the viscosity of the oil they were using, all but 6 of these 30 operators were using the viscosity recommended by the manual. This fact suggests that petroleum salesmen are doing a conscientious job of supplying their customers with oil of the correct viscosity.

Forty-five of the 51 operators were using a detergent oil of MS-DG or DS classification.

BRAKE ADJUSTMENT

Twenty-five of the 60 tractors were in need of brake adjustment. The brake adjustment on 19 of these tractors was uneven, causing one wheel to receive most of the braking when the pedals were locked together. In view of our present tractor speeds, improper brake adjustment can affect the safety of the operator.

Only three of the ten manuals gave a recommended time interval for inspection of brake adjustment; the other seven manuals explained only how to make the adjustment. Of twenty operators who owned tractors for which a definite inspection interval was specified, only one man knew the manual recommendation. This fact points up the need for better operator education concerning the importance of regular brake adjustment inspection. The recommendation for brake adjustment should contain the interval for inspection and the tolerable limits of wear before adjustment should be made.

TIRE PRESSURE

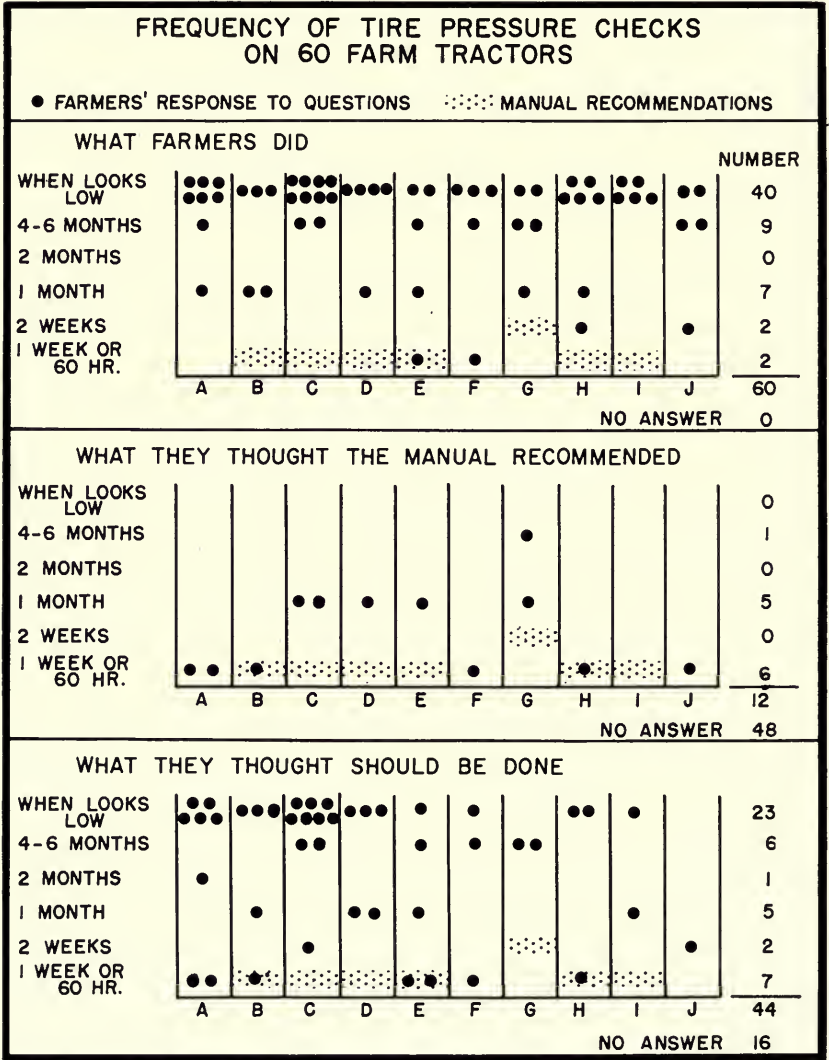
Of the 120 front tires inspected, 63 had inflation pressures that were more than 4 p. s. i. from the recommended pressure. On 34 of these tires the pressure was too high and on 29 the pressure was too low.

Only 60 of the 120 rear tires had inflation pressures that were in the 12 to 16 p. s. i. range. Fifty-one of the 120 tires had less than the old recommendation of 12 p. s. i. minimum pressure.

Three of the ten manuals did not contain a recommended interval for tire pressure checks. Of the 41 operators who had tractor manuals with a tire pressure interval recommendation, only 8 operators volunteered knowledge of the manual recommendation and 5 of these were more than 100 percent off in their estimate of the service interval (Fig. 5).

Most operators check tire pressures and add air only when tires "look low." Operators need to be educated to regular use of a pressure

gage and to become familiar with new recommendations of the Tire and Rim Association. At least one manufacturer now uses decals to post the recommended tire pressure on the machine—a practice that should be encouraged.



Few operators used a gage to check tire pressure. As a result, rear tire pressures were too low. (Fig. 5)

IGNITION POINT CONDITION

Ignition points were found to be excessively pitted on 27 of the 55 tractors with ignition systems. Point gap was correct on 27 tractors, too large on 4, and too close on 17. Of the 17 tractors with point gaps that were too small, 13 had pitted points. All tractors with dirty or dry cams had pitted points, indicating that wear of the ignition point fiber block and closing of the point gap may be a major cause of point pitting.

Only four of nine tractor manuals recommended an interval for ignition point inspection. These recommendations varied from 200 to 700 hours. One manual had conflicting recommendations. Thirteen operators inspected ignition points yearly, 9 twice a year, and others inspected points only "when needed" or not at all.

All tractor manuals should not only include a standardized interval for point inspection, but should also stress the importance of good ignition point condition. Longer point life could undoubtedly be achieved if the breaker cam received proper lubrication.

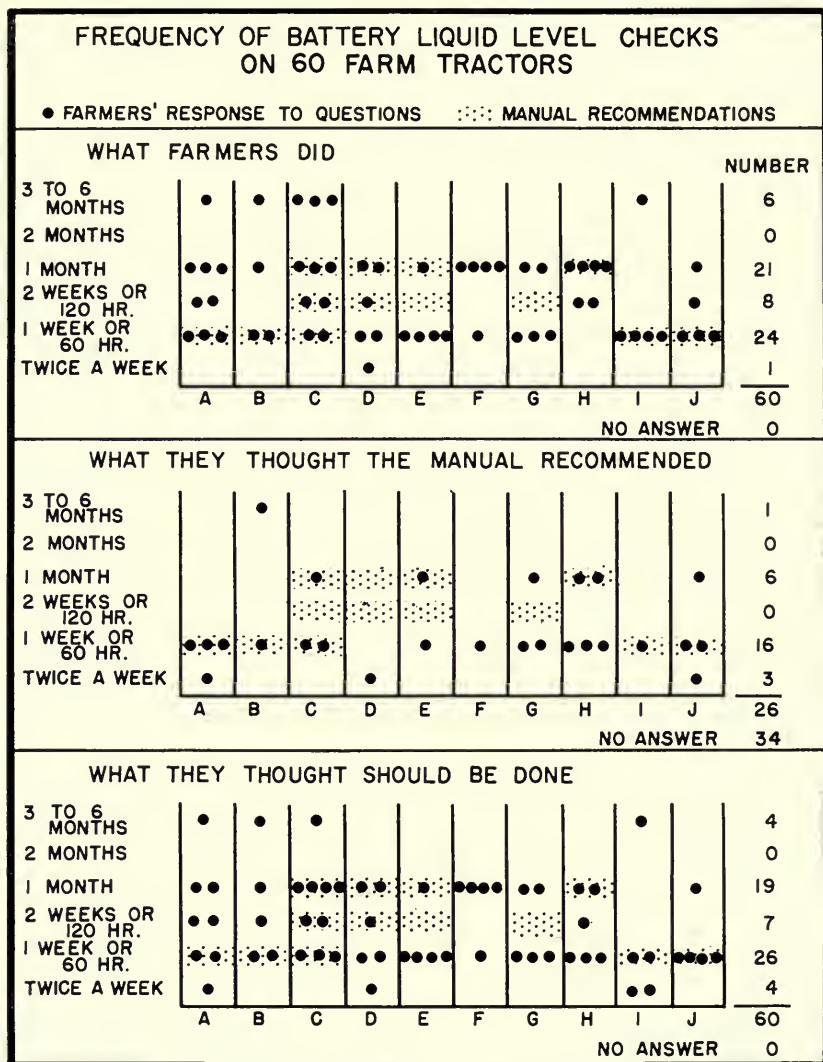
BATTERY LIQUID LEVEL

The battery liquid level was low on 27 of the 60 tractors. On 16 of these tractors the liquid level was below the top of the plates. Twelve of the 16 also had corroded terminals. Models A, F, and I each had three batteries with the liquid level below the plates, and models A and F had significantly shorter battery life than the other models.

Manual recommendations for interval of battery inspection varied from a week to a month (Fig. 6). One manual listed three different intervals. Despite the diversity of recommendations, operators were following them fairly well. But only half of the 26 operators who volunteered knowledge of the manual actually knew the recommendations for their tractors. Ten of the operators who said that they were following manual recommendations had batteries with the liquid level below the plates.

No relationship existed between frequency of battery service and the battery's liquid level at the time of inspection. This fact might indicate that each battery and electrical system had its own required frequency for adding water. If it is impossible to reach a standardized recommendation for all tractors, then the individual recommendation must be spelled out clearly, and conflicting recommendations should never appear in the same manual. Importance of maintaining the liquid level above the plates should also be stressed.

Thirty-three of the 60 operators were using well water in their tractor batteries. The type of water used apparently had no significant effect on battery life.



Although operators followed manual recommendations fairly well, the battery liquid level was low on 27 tractors. (Fig. 6)

CARBURETOR FLOAT LEVEL

Eleven of the 50 tractors with carburetors had poor float level adjustments. Four of the 8 tractors with float levels $\frac{1}{4}$ inch too high were of tractor model G. All 3 of the tractors with float levels $\frac{1}{4}$ inch too low were of tractor model E.

Since the operator is not responsible for adjusting the float level, this adjustment should be checked during the dealer's tuneup and when a mechanic is "trouble shooting" on a tractor with poor performance.

AIR CLEANER SERVICE

Service of air cleaner cup. Forty-six of the 60 tractors had more than $\frac{1}{4}$ inch of dirt in the air cleaner cup. Seventeen of these tractors had more than $\frac{1}{2}$ inch of dirt.

Although 39 operators said that the manual recommended daily service of the air cleaner, only 9 operators were actually following this practice. The largest group believed that twice-a-week inspection and change of oil was sufficient.

Daily air cleaner service takes about 480 minutes a year, or about 13 percent of the total time required for on-the-farm tractor maintenance (Table 7, pages 30-31). All but one manual recommended daily inspection and change of the air cleaner oil; yet only 23 operators changed oil oftener than once a week. The oil level in 2 cleaners was more than $\frac{1}{2}$ inch low. In 19 others the level was $\frac{1}{4}$ to $\frac{1}{2}$ inch low.

Compliance with recommendations is much better when these recommendations are realistic. To make the air cleaner cup recommendation more realistic, it is suggested that manufacturers continue to recommend daily inspection but recommend oil change only when the dirt has accumulated to a certain depth or the oil has thickened.

The operator will not take the time or use the oil necessary for daily service if he finds that he is throwing away oil from a clean cup. Some method of checking the cup without removing it would allow quick daily inspection. Manufacturers are now testing transparent plastic air cleaner cups. Dry-type air filters, which are also being field-tested, are easier to service than ordinary oil bath cleaners, but may require as much total service time because of a limited capacity for dirt.

Service of air cleaner body. Air cleaner vacuum or amount of restriction was found by measuring the pressure between the air cleaner and carburetor with a water manometer. The manometer readings showed that most gasoline engines containing throttle plates have less than 3 inches of water vacuum at full-throttle no-load when the air cleaners are kept clean. Diesels have considerably higher readings because air flow is not restricted by a throttle plate.

The manometer readings for gasoline tractors with restrictions were as high as 8 inches at full-throttle no-load. Seven of the 60 air cleaners were excessively restricting the flow of incoming air, and 5 of these 7 restricted air cleaners were found on models A and F. Restriction was

caused by dirt in the cleaner body. A visual inspection of the bottom of the air cleaner elements proved inadequate; upon inspection, 2 of the 7 restricted air cleaners appeared to be clean.

Manual recommendations for complete cleaning of the air cleaner varied from 60 hours to once a year. The state of operator education on these recommendations was very poor. Thirty-six operators had no idea of what the recommendation might be. Thirty-five of the 60 operators said that they had never removed the air cleaner or given it a complete cleaning. Operators of 6 of the 7 tractors with restricted air cleaners were in this group.

If all manufacturers would adopt a standardized service interval of one year for cleaning the air cleaner body, it would be easier to convince farmers of the importance of this maintenance chore. It should be possible to design the air cleaner so that it can be completely cleaned without removing it from the tractor.

VALVE CLEARANCES

On most tractors the clearances on both the intake and exhaust valves were greater than those specified by the manual. For example, the intake valve on the No. 1 cylinder had too large a clearance on 20 of 55 tractors and too small a clearance on only 7. The exhaust valve on the No. 1 cylinder had too large a clearance on 28 of 55 tractors and too small a clearance on only 8.

This apparent tendency of valve clearances to increase with tractor use agrees with results obtained in a controlled study of valve clearances on 60 tractors (6). However, Smith and Larsen (5) found that the tractors in their study had less than specified valve clearance at the time of inspection.

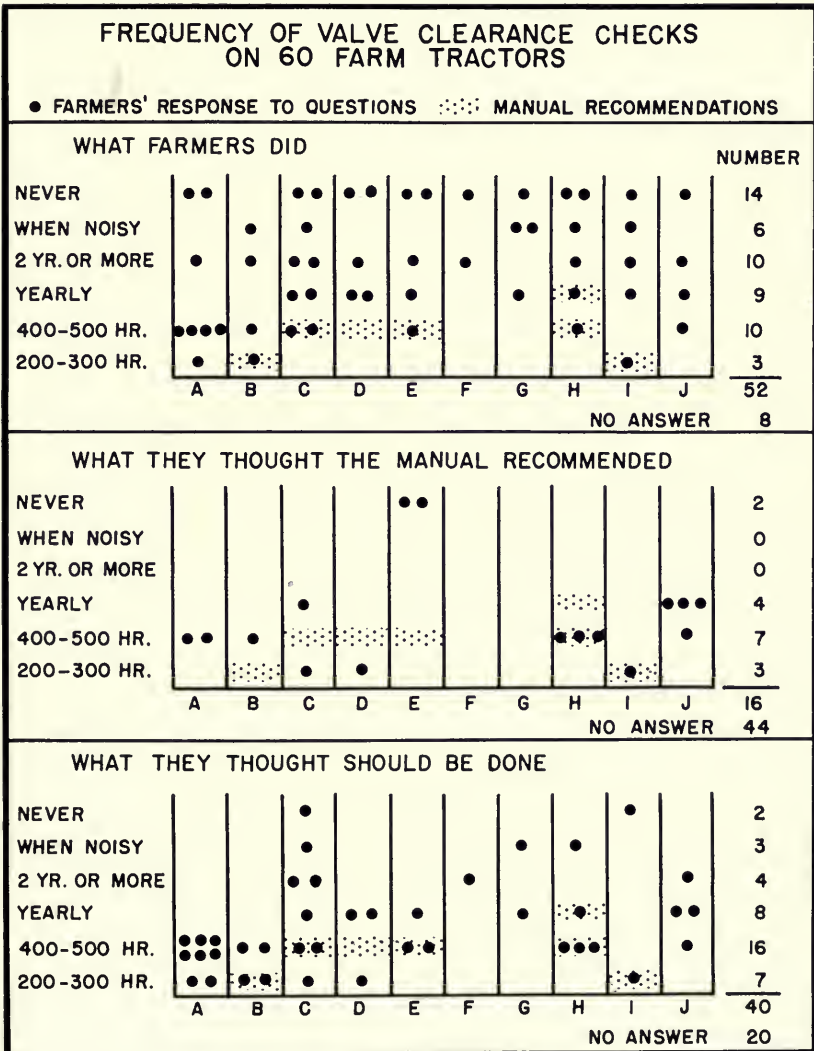
In six of ten manuals, recommendations on frequency of valve clearance checks varied from 250 to 400 hours (Fig. 7). Other manuals recommended adjustment "periodically" and "occasionally," or instructed the operator to "maintain clearance."

Only 16 of 60 operators volunteered answers on recommended frequency of valve clearance checks. The operators' actual practices diverged widely from manual recommendations, with 20 of the 60 operators either adjusting the valves only "when they were noisy" or neglecting them completely.

Since mechanics often use larger than specified clearance in an attempt to prevent valve trouble, some operators were doubtful about the amount of clearance to use. If a manufacturer changes the recommendation for valve clearance from that specified in the manual, this

information should be distributed to all owners of that particular model tractor.

Valve adjustment requires precision, and it is difficult for an untrained person to perform this chore correctly. But if recommendations could be standardized to once-a-year intervals, valve adjustment could be made a part of the dealer's yearly tuneup.



Operators' knowledge of manual recommendations was poor, and their actual practices varied widely from these recommendations. (Fig. 7)

Hydraulic lifters would eliminate the need for valve clearance adjustment. One requirement for hydraulic lifters is the use of detergent oil. The fact that 45 of the 51 operators interviewed were already using detergent oil suggests that the switchover to oil for hydraulic lifters would probably not be difficult.

CRANKCASE BREATHERS

Crankcase breathers had the poorest maintenance record of the tractor items inspected. Thirty-two of 54 breathers were dirty, and 12 of these were apparently plugged with dirt.

Operators' manual recommendations varied in frequency of service from "daily" to "no service required"; the term "periodic" was used in one manual. Thirty-four of 48 operators were unable to volunteer an answer as to the frequency of service required, and several were not aware that their tractors had a crankcase breather.

One tractor manufacturer has eliminated crankcase breather maintenance, and it would be desirable if all tractor manufacturers could follow his example. The value of designing construction machinery for ease of maintenance was stressed by Navarin and Usow (3). The same principle applies to farm tractors.

TRANSMISSION OIL CHANGE

Although transmission oil change is not considered a critical maintenance chore, it illustrates a relationship between state of operator education and actual practice that should be considered when making up any manual recommendation.

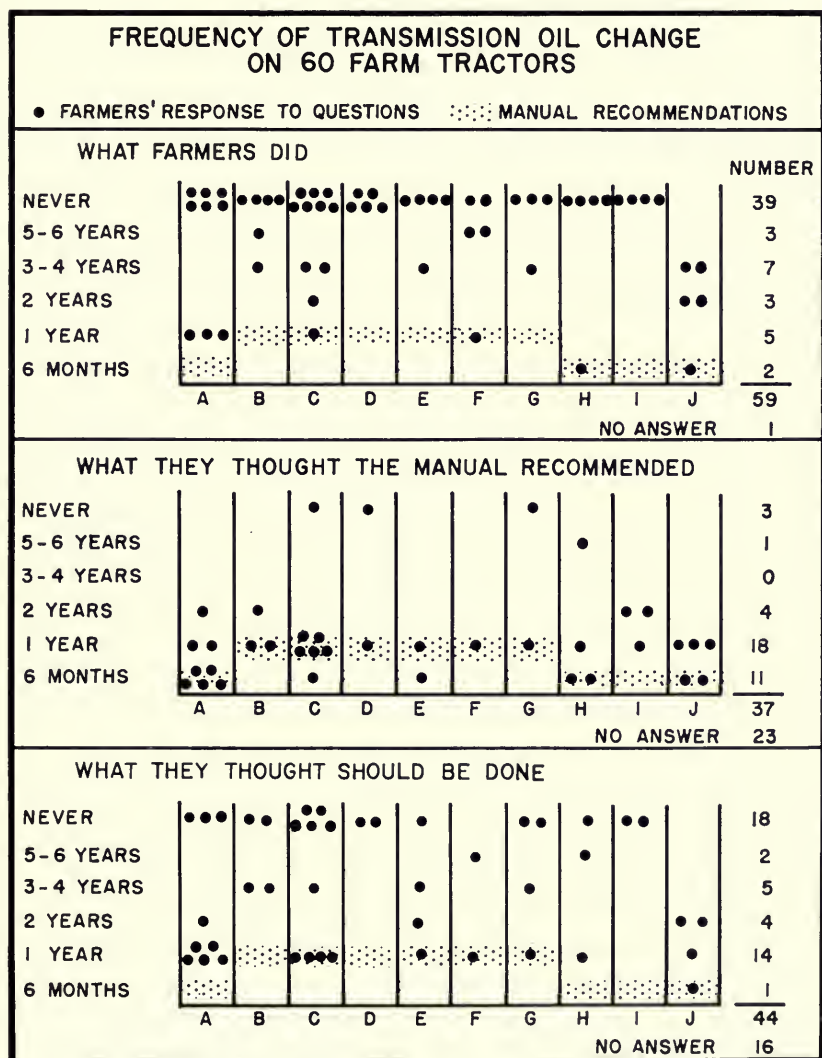
Thirty-nine of 59 operators never changed transmission oil. Most operators who answered the question (29 of 37) knew the recommendation of six months or one year, but only 15 of 44 operators thought it necessary to change oil as often as once a year (Fig. 8).

The transmissions of 5 of the 60 tractors inspected had been overhauled; yet the operators of 2 of these tractors were changing transmission oil at the recommended one-year interval. The frequency with which the 60 operators changed transmission oil had no apparent relationship to their transmission system difficulties.

Transmission oil change is expensive, messy, and time-consuming, and even the operators who knew the recommendation preferred to take the risk involved in disregarding it.

The recommendation for transmission oil change illustrates the need for carefully examining each tractor maintenance recommendation.

Any recommendation that is not completely realistic or has a higher frequency than necessary will probably not only be disregarded, but will also detract from the appreciation of the importance of other maintenance chores.



Twenty operators knew the manual recommendation, but only four of these operators were actually following it. Thirty-nine operators never changed transmission oil. (Fig. 8)

Table 6. — Variation in Recommended Maintenance Intervals as Related to the Operators' Knowledge of These Intervals

(Recommendations taken from operators' manuals of ten tractor models, A thru J)

Items (Listed in order of operators' compliance with manual recommendations)	Tractor models	Shortest time interval	Tractor models	Longest time interval	Models with no specific recommen- dations
Air cleaner cup check.....	.....	.....	A, B, C, D, E, F, G, H, I, J	daily	.....
Engine oil level check.....	I	twice daily	A, B, C, D, E, F, G, H, J	daily	.....
Radiator level check.....	.....	.....	A, B, C, D, E, G, H, I, J	daily	F
Air cleaner oil change.....	A, B, C, D, E, F, H, I, J	daily	G	when dirt $\frac{1}{4}$ " deep	.....
Engine oil change (Gasoline models).....	H	60 hours	C, D, E, G	120 hours	.....
Transmission oil change.....	A, H, I, J	6 months	B, C, D, E, F, G, H	yearly	.....
Generator lubrication.....	G, H, I, J	60 hours	B, F	300 hours	.....
Engine oil filter change.....	B, C, D, E, G	at oil change	H	at third oil change	.....
Grease fittings, rear axle.....	B, C, D, E, G, H, J	daily	F	1800 hours	.....
Water pump or fan lubrication.....	C, D, E	daily	A, H, J	not required	F
Front wheel lubrication.....	A	30-60 days	G	yearly	.....
Battery level check.....	A, B, I, J	weekly	H	monthly	F
Radiator flush.....	H	90 days	B, D, E, G	yearly	A, F, G
Steering gear oil level.....	A, J	30-60 days	C, D, E, G	yearly	F, I
Clutch lubrication.....	A, I	daily	B, F, G, J	not required	.....
Hydraulic system, oil change.....	A	6 months	B	1000 hours	I
Crankcase breather service.....	A, F	daily	G	not required	H, J
Air cleaner, complete cleaning.....	C, D, E	60 hours	A, F	yearly	G, H, I, J
Distributor point check.....	H	200 hours	C, D, E	500 hours	A, B, F, G, I
Spark plug inspection.....	A	200	B, C, D, E	250 hours	F, G, H, I
Starter lubrication.....	I	60	A, F, G, H, J	not required	.....
Valve clearance check.....	B	250 hours	H	yearly	A, F, G, J
Distributor lubrication.....	F	days	G	not required	B
Tire pressure check.....	B, C, D, E, G, H	weekly	G	yearly	A, F, J
Clutch adjustment.....	C, D, E	400 hours	G	2 weeks	A, B, F, H
Steering gear oil change.....	F	200 hours	C, D, E	1000 hours	A, H, I, J
Brake adjustment.....	C, D, E	400 hours	.....	.....	A, B, F, G, H, I, J

OPERATORS' MANUALS AND TRACTOR DESIGN

The manual recommendations for the ten models used in this study appear in Table 6. These recommendations are listed in descending order of the operators' knowledge of them. In determining this order, both the number of operators who gave the correct answer and the number who gave no answer at all were considered. Only those operators having manuals with specific recommendations were included. Since 65 percent of the operators gave the correct answer of "daily service" for the air cleaner cup, this item is listed first in Table 6. Brake adjustment appears last in Table 6 because only 5 percent of the operators with manuals giving a recommendation for brake adjustment knew the recommendation.

Two factors appear to influence the state of operator education on any particular item:

1. The degree of standardization of the recommendation among tractor models.
2. The number of manuals containing a specific recommendation on frequency of service.

For example, all ten manuals recommended daily inspection of the air cleaner cup. Since the recommendation is standardized, all information disseminated on this subject by manufacturers, fuel companies, and extension workers is in agreement, and the result is a satisfactory state of education among tractor operators. For crankcase breather check, on the other hand, recommendations vary from "daily" to "no service required" and operator education is poor.

Operator education was high for the items listed in the first part of Table 6, and all ten manuals recommended a definite service interval for most of these items. In contrast, only four, five, or six of the ten manuals contained recommendations for many of the items in the latter part of Table 6. As a result, even those operators who had manuals with recommendations did not know these recommendations.

About 60 hours a year, or 10 percent of the yearly tractor operating time, is required to follow manual recommendations to the letter. For a breakdown of the estimated time required for lubrication and maintenance of tractor model C, see Table 7. Analysis of other manuals gave similar results.

Comparison of the manual recommendations and the actual practices of these 60 operators (Table 3) shows that they spent much less than 60 hours per year on tractor maintenance. A previous study by R. I. Shawl (4) revealed that one owner averaged 33 hours of maintenance chore time per year for 18 years. Since farmers are spending

Table 7. — Estimated Time Required for One Year's Lubrication and Maintenance of Tractor Model C

(The schedule in this table was taken directly from the operator's manual for tractor model C. It is based on 600 hours of operation per year.)

Services	Minutes required per service	Number of services per year	Total minutes re- quired
Daily or 10 Hours			
Air cleaner oil cup, inspect and change.....	8	60	480
Engine oil level, check and add.....	3	60	180
Radiator level, check and fill.....	2	60	120
Air cleaner cap, check and clean.....	1	60	60
Grease fittings:			
Water pump shaft.....	1	60	60
Rear axle bearings.....	1	60	60
Steering mechanisms.....	4	60	240
Clutch shaft.....	1	60	60
Starting crank bearing.....	1	60	60
Bolster bearing.....	1	60	60
	<u>23</u>		<u>1380</u>
Weekly or 60 Hours			
Air cleaner body, remove and clean.....	60	10	600
Fan belt, check tension.....	1	10	10
Generator belt, check tension.....	1	10	10
Radiator fins, clean.....	15	10	150
Storage battery, check level and fill.....	20	10	200
Grease fittings:			
Water pump bearing.....	1	10	10
Clutch release bearing.....	2	10	20
Clutch pilot bearing.....	5	10	50
Tires, ^a check pressure and inflate.....	10	10	100
	<u>115</u>		<u>1150</u>
120 Hours			
Crankcase oil, change.....	20	5	100
Oil filter element, change.....	15	5	75
Generator, lubricate.....	5	5	25
	<u>40</u>		<u>200</u>
250 Hours			
Crankcase breather, remove and clean.....	30	3	90
Spark plug, remove and clean.....	30	3	90
Fuel strainer and sediment bowl, clean.....	5	3	15
	<u>65</u>		<u>195</u>
300 Hours			
Starting motor, lubricate.....	5	2	10
Distributor cap, clean ^a	10	2	20
	<u>15</u>		<u>30</u>
400 Hours			
Fuel line screen, clean.....	10	2	20
Engine valves, adjust.....	120	2	240
Clutch pedal, adjust.....	10	2	20
Brakes, adjust.....	20	2	40
Cooling system, flush and clean.....	30	2	60
	<u>190</u>		<u>380</u>

^a Not on maintenance guide sheet, but in the text of the manual.

Table 7. — concluded

Services	Minutes required per service	Number of services per year	Total minutes re- quired
500 Hours			
Distributor breaker points, inspect.....	15	2	30
Distributor, lubricate.....	15	2	30
	30		60
6 Months			
Front wheels, repack.....	90	2	180
	90		180
1000 Hours			
Steering worm gear, change oil.....	50	1	50
Transmission and differential, change oil.....	50	1	50
	100		100
Total time required to maintain tractor one year.....		minutes hours	3675 61.2

less time on maintenance chores than recommended by the manuals, it would seem desirable to reduce the number of chores and make the essential ones as easy to perform as possible. For example, the air cleaner, battery, steering mechanism, and valves currently require a great deal of maintenance time (Table 7); making these items easier to service would substantially decrease total maintenance time.

Most companies are making an effort to reduce maintenance time. For example, on one current model tractor the battery can be moved to an accessible location and the liquid level checked without the use of wrenches. On the other hand, the generator of another current model cannot be lubricated without removing the hood, a process that necessitates the removal and replacement of eight screws with a special tool. Needless to say, this practice discourages proper generator lubrication.

Comparatively few of the maintenance chores were standardized among various tractor makes and models. Table 7 shows intervals of 10, 60, 120, 250, 300, 400, 500, and 1,000 hours, and the operators in this study did not follow manual recommendations closely enough to justify so many maintenance intervals. Most operators did not recognize the difference between 250 and 300 or between 300 and 400 hours.

The number of intervals should be kept to a minimum and could well be multiples of the crankcase oil change time. If the intervals were multiples, the operator could easily comply with recommendations.

The following suggested schedule could serve as a guide for standardizing recommendations on an industry-wide basis. It is set up in

multiples of 100 hours. For example, at 200 hours, the operator would also perform the 100-, 50-, and 10-hour chores.

The crankcase breather and other items for which current recommendations vary widely are not listed in this schedule. Transmission, steering gear, and power lift oil change have also been omitted. Studies should be made to determine if these services are really necessary. If they are necessary and farmers will not perform them, then tractors should be designed either to simplify these services or eliminate them. For example, a lifetime filter could be built into the transmission.

10 Hours (Daily)

Engine oil level check

Radiator level check

Air cleaner cup inspection (change oil and clean cup when dirt reaches $\frac{1}{4}$ " to $\frac{1}{2}$ " depth or oil becomes contaminated)

Grease fittings, steering, rear axle, etc.

50 Hours (One Week)

Battery liquid level check

Hydraulic system level inspection

100 Hours (Two Weeks)

Engine oil change

Engine oil filter change (or at 200 or 300 hours)

Tire pressure check

Generator lubrication

200 Hours (One Month)

Spark plug inspection

Ignition points inspection

Distributor and cam lubrication

Belt tension checks

Starter lubrication (if required)

Fuel strainer and sediment bowl

400 Hours (Two Months)

Valve clearance check

Transmission oil level check

Steering gear oil level check

Air cleaner, complete cleaning

Yearly

Clutch adjustment inspection

Brake adjustment inspection

Front wheels, clean and repack bearings

Governor speed check

Engine timing check

Radiator flush

Dealer tuneup

RECOMMENDATIONS

This study of tractor manuals as related to the practices and opinions of the operators and the condition of their tractors is the basis for the following recommendations.

STANDARDIZING MAINTENANCE INTERVALS

All manufacturers should attempt to standardize the maintenance intervals for as many parts as possible. These maintenance intervals could be set up for daily service and in multiples of the time for crank-case oil change. Sixty hours or multiples of 60 hours cause confusion, but an interval of 100 hours is easy to determine on hour meters and odometers.

To facilitate standardization of recommendations and to further investigate improved maintenance, it is suggested that the Farm Equipment Institute, American Society of Agricultural Engineers, and Society of Automotive Engineers establish a joint committee that would include representatives from all tractor manufacturers. This committee would have objectives similar to those of the CIMTC Ease of Maintenance subcommittee of the Society of Automotive Engineers.

MAKING RECOMMENDATIONS REALISTIC

Manufacturers should critically review each recommendation to make sure that it is both practicable and realistic. They should also encourage their designers to eliminate as many maintenance chores as possible and to make necessary chores easy to perform.

IMPROVING INSTRUCTION MANUALS

Those responsible for compiling and editing service manuals should be certain that their manuals contain only one specific recommendation for each item. Conflicting statements confuse the reader and leave him with no definite impression of what to do.

Terms such as "periodic," "occasionally," "when needed," "frequently," "at intervals," and "maintain clearance" mean little to the farmer and should not be included in tractor manuals.

Inspection intervals should be spelled out in actual hours of time, and limits of adjustment or condition should be given in such terms that the operator knows whether adjustment or service is needed at the time of inspection.

Instruction manuals should also contain one page that lists all the lubrication and maintenance intervals and all the items to be serviced at each interval.

FASTENING METAL REMINDERS ON TRACTORS

Since many farmers seldom refer to their instruction manuals but need a constant reminder of necessary maintenance chores, it is also suggested that an abbreviated maintenance schedule be placed on a metal plate and fastened to the tractor dash in full view of the operator. This plate and the hour meter might be color coded to make them easy to read. (See Fig. 9 for an example of an abbreviated schedule.)

A metal plate might also be used to designate spark plug gap, ignition point clearance, valve clearances, and special recommendations when one manufacturer's recommendation differs widely from those of other manufacturers. Tire manufacturers could also return to the practice of molding minimum inflation pressure into the sidewalls of their tires.

IMPROVING COMMUNICATION BETWEEN FARMERS AND MANUFACTURERS

Tractor maintenance is not just the concern of an individual company for its own tractor—it is a problem that affects the entire industry. To teach the farmer proper maintenance practices, each company needs the cooperation of other tractor companies, the oil companies, and college extension workers.

Farm tractor manufacturers, particularly those who design parts and determine maintenance chores, can do much to improve tractor care.

Petroleum salesmen contact farmers frequently and could help with maintenance problems if their companies would provide them with training and literature on tractor care.

Service engineers and extension workers should keep close liaison with tractor manufacturers in order to maintain a steady flow of information in both directions. Tractor troubles resulting from maintenance deficiencies should be reported to the company engineers.

The operator should be given a reason for following the recommendation, and manuals, maintenance bulletins and circulars, and statements by extension workers, service engineers, and petroleum salesmen should tell *why* a particular chore needs to be done.

Since many of the neglected maintenance chores have a yearly interval of service, the dealer's yearly tuneup should also be encouraged.

OPERATOR'S		SERVICE	GUIDE
10 Hours Or Daily	Engine Oil Level Check	Above 32°-SAE 20, Below 32°-SAE 20 W - MS DG Fill To Level With Eng. Oil - Clean At 1/4" Dirt Wash In Kerosene - Dip In Motor Oil 8 Fittings - Chassis Lube Drain Antifreeze For Summer Operation	
	Air Cleaner Cup Check		
50 Hours	Crankcase Breather Service	Maintain 1/4" Above Plates Above 45°-SAE 20W, Below 32°-SAE 10 W	
	Grease Fittings		
100 Hours	Radiator Level Check	Capacity 6 Qts. - 7 Qts. With Filter Change Same Oil As Engine - 2 Drops Front 28 - Rear 14	
	Battery Liquid Level Check		
200 Hours	Hydraulic Oil Level Check	Gap .020 Grease Cam Sporingly - Chassis Lube Gap .028 To .032 1" Free Movement Take Apart And Clean	
	Engine Oil & Filter Change		
400 Hours	Generator Lubrication	Remove From Tractor - Clean With Kerosene Fill To Level Plugs - SAE 80 EP Worm Gear 1/3 Covered - SAE 140 Exhaust & Intake .012 - Hot	
	Tire Pressure Check		
Yearly	Distributor Points Inspection	Clutch And Brake Adjustment, Hydraulic Oil Change Governor Speed And Engine Timing Check Front Wheels Repack And Radiator Flush Transmission, Final Drive & Steering Gear Oil Change	
	Distributor & Cam Lubr.		
Yearly	Spark Plug Inspection	FOR DETAILS SEE YOUR OPERATOR'S MANUAL	
	Belt Tension Check		
Yearly	Fuel Filter & Sediment Bowl		
	Air Cleaner Complete Cleaning		
Yearly	Transmission & Final Drive Oil Levels		
	Steering Gear Oil Level		
Yearly	Valve Clearance Check		
	Clutch And Brake Adjustment, Hydraulic Oil Change		
Yearly	Governor Speed And Engine Timing Check		
	Front Wheels Repack And Radiator Flush		
Yearly	Transmission, Final Drive & Steering Gear Oil Change		

PROVIDED
FOR COLOR
CODING

SIZE OF
METAL
PLATE
4" x 6"

Example of an abbreviated maintenance schedule for a metal plate to be fastened to the tractor. (Fig. 9)

SUMMARY

In the summer and fall of 1955, 60 tractors (ten models representing eight different makes) on farms in central Illinois were inspected for evidence of good or poor maintenance practices. During the inspection, the operator was questioned on his knowledge of the manual recommendation for each maintenance item, his opinion as to how often the item should be serviced, and his actual practice in servicing it.

Analysis of the inspections and operator interviews revealed the following results:

1. Maintenance chores were being neglected.
2. Operators of all ages gave their tractors about the same degree of care, and there was little difference in the maintenance levels of the ten models.
3. The most frequent maintenance deficiencies were dirty crankcase breathers and air cleaners, batteries with liquid level below the plates, low tire pressure, improper valve adjustment, pitted ignition points, poorly adjusted brakes, excessive engine speed, and crankcase oil that needed changing.
4. To improve maintenance, each of these items must be considered separately. Most operators were following manual recommendations for battery care and crankcase oil change. Only a few operators were following manual recommendations for air cleaner and crankcase breather service, tire pressure check, and valve clearance adjustment.
5. The life of spark plugs, valves, batteries, pistons, rings, sleeves, and certain other parts varied more among tractor models than between tractors of the same model.
6. The fact that an operator knew a certain recommendation did not necessarily mean that he was following it. Many recommendations were not followed because the operator felt that they were unnecessary, time-consuming, messy, or expensive.
7. Operator education was best on those items for which the manual recommendation was both standardized and specific. Operator education was poorest on those items for which there was no manual recommendation or no standardization of the recommendation among tractor manuals.
8. Following present manual recommendations to the letter requires about 60 hours a year or 10 percent of the tractor's operating time. The farmers interviewed in this study were spending much less than 60 hours a year on tractor maintenance.

APPENDIX

SUMMARY OF TRACTOR INSPECTIONS

Not all items were inspected on all 60 tractors because some tractors did not contain certain parts. For example, a Diesel tractor does not have spark plugs.

<i>Item inspected</i>	<i>Number of tractors</i>	<i>Item inspected</i>	<i>Number of tractors</i>
Air cleaner, vacuum test^a		Battery condition	
O.K. 0 to 3" H ₂ O.....	41	O.K.....	26
3 to 5".....	4	Corroded terminals.....	32
Over 5".....	4	Loose terminal.....	1
Air cleaner, precleaner or screen		Loose in holder.....	2
Clean.....	43	Corroded box.....	1
Needed cleaning.....	15	Defective cable.....	1
Contained oil.....	1	Brakes, adjustment	
Broken.....	1	O.K.....	35
Air cleaner, dirt in bowl		Needed adjustment.....	25
O.K.....	14	Uneven.....	19
$\frac{1}{4}$ " to $\frac{1}{2}$ " of dirt.....	29	Pedal stuck.....	1
Over $\frac{1}{2}$ " of dirt.....	17	Carburetor, load adjustment	
Air cleaner, oil level		O.K.....	40
O.K.....	39	Too rich.....	9
$\frac{1}{4}$ " to $\frac{1}{2}$ " low.....	19	No response to adjmt.....	1
Over $\frac{1}{2}$ " low.....	2	Carburetor, idle adjustment	
Air cleaner, oil viscosity		O.K.....	32
SAE 10.....	3	Too fast.....	6
SAE 20.....	38	Too slow.....	1
SAE 30.....	18	Too rich.....	11
Air cleaner body		Too lean.....	1
Clean.....	29	No response to adjmt.....	8
Dirty.....	27	Carburetor float level	
Nearly plugged.....	2	O.K. $\pm \frac{1}{16}$ ".....	27
Hole in inlet.....	2	$\frac{1}{8}$ " high.....	11
Air cleaner hose		$\frac{1}{4}$ " high.....	8
O.K.....	44	$\frac{1}{8}$ " low.....	1
Loose.....	1	$\frac{1}{4}$ " low.....	3
Defective clamp.....	10	Clutch free play	
Battery liquid level		O.K.....	47
O.K.....	33	Too much.....	8
High.....	0	Not enough.....	3
Low.....	27	Pedal stuck.....	2
Below plates.....	16	Pedal bearing worn.....	2
Battery hydrometer reading		Crankcase breather	
1.28 to 1.25.....	30	O.K.....	10
1.25 to 1.22.....	7	Dirty.....	32
1.22 to 1.19.....	5	Apparently plugged.....	12
1.19 to 1.16.....	3	Differential oil level	
Below 1.16.....	1	O.K. $\pm \frac{1}{4}$ ".....	43
		$\frac{1}{4}$ " to $\frac{1}{2}$ " high.....	4
		$\frac{1}{4}$ " to $\frac{1}{2}$ " low.....	3
		Over $\frac{1}{2}$ " low.....	10

^a Test made at full-throttle, no-load speed.

<i>Item inspected</i>	<i>Number of tractors</i>	<i>Item inspected</i>	<i>Number of tractors</i>
Distributor cap		Engine timing	
O.K.....	40	O.K. ± 3 degrees.....	41
Corroded terminals.....	7	4 to 8 degrees slow.....	6
Dirty.....	3	8 to 12 degrees slow.....	2
Corroded rotor.....	1	4 to 8 degrees fast.....	4
Dust cap broken.....	1	8 to 12 degrees fast.....	1
Distributor points		Fan belt condition	
O.K.....	19	O.K.....	31
Pitted.....	27	Defective.....	18
Worn.....	4	Too loose.....	19
Misaligned.....	1	Too tight.....	5
Distributor point gap		Front wheel bearing adjustment	
O.K. $\pm .002$	27	O.K.....	38
.002 to .005 too wide.....	1	Too loose.....	19
Over .005 too wide.....	3	Left.....	7
.002 to .005 too close.....	11	Right.....	6
Over .005 too close.....	6	Front wheel bearing lubrication	
Distributor cam		O.K.....	48
O.K.....	29	Repacking needed.....	4
Dry.....	3	Front wheel bearing seal	
Excessive lubrication.....	13	O.K.....	51
Dirty.....	4	Needed replacement.....	4
Engine oil pressure		Fuel filter	
Normal.....	55	O.K.....	6
High.....	2	Dirty.....	28
Gage not working.....	3	Damaged.....	2
Engine oil level		Fuel sediment bowl	
O.K.....	32	Clean.....	7
1 quart low.....	22	Contained water.....	8
More than 1 quart low.....	5	Dirty.....	48
1 quart high.....	1	Leaking.....	2
Engine oil viscosity		Gaskets (leaking)	
SAE 10.....	3	Valve cover.....	7
SAE 20.....	42	Crankcase.....	7
SAE 30.....	14	Cylinder head.....	2
SAE 40.....	1	Differential.....	3
Engine oil acidity		Transmission.....	4
Alkaline 1.....	5	Hydraulic system.....	4
2.....	11	Rear axle.....	1
Neutral 3.....	30	Belt pulley seal.....	1
4.....	11	Front bolster.....	1
Acid 5.....	3	Carburetor.....	1
Engine oil spot test		Generator belt condition	
Clean.....	39	O.K.....	34
Carrying light dirt load.....	13	Defective.....	19
Carrying heavy dirt load.....	8	Too loose.....	21
Dispersing O.K.....	56	Too tight.....	2
Dispersing inadequately.....	3	Generator and regulator	
Silica present.....	11	O.K.....	57
Needed change.....	24	Excessive charge.....	1
Engine oil filter		Not charging.....	2
O.K.....	29	Governor no-load speed	
Needed change.....	11	O.K. ± 30 engine r.p.m.....	18
No filter.....	1	30 to 60 too fast.....	8

<i>Item inspected</i>	<i>Number of tractors</i>	<i>Item inspected</i>	<i>Number of tractors</i>
Governor no-load speed—<i>cont.</i>		Spark plug condition	
Over 60 too fast.....	24	O.K.....	49
30 to 60 too slow.....	1	Cracked porcelain.....	3
Over 60 too slow.....	5	Too loose.....	2
Hydraulic system condition		Gasket missing.....	2
O.K.....	53	Spark plug deposits	
Leaking.....	4	Clean.....	21
Hydraulic system oil level		Lead deposits.....	16
O.K.....	25	Carbon deposits.....	18
Low.....	25	Fouled.....	4
High.....	3	Spark plug gaps	
PTO clutch adjustment		O.K. $-.002$ to $+.005$	20
O.K.....	57	Under $-.002$	0
No PTO clutch.....	3	Over $+.005$	35
Radiator cap and overflow		Steering gear adjustment	
O.K.....	57	O.K.....	30
Defective.....	3	Too loose.....	30
Radiator leaking.....	3	Tire condition, front	
Overflow defective.....	4	Practically no wear.....	18 ^a
Radiator screen		Moderate wear.....	66
Clean.....	36	Excessive wear.....	35
Dirty.....	5	Damaged.....	18
Damaged.....	4	Cracked.....	4
No screen.....	15	Tire pressure, front	
Radiator fins		O.K. ± 2 p.s.i.....	45 ^a
Clean.....	24	3 and 4 p.s.i. low.....	4
Dirty.....	36	Over 4 p.s.i. low.....	29
Bent.....	2	3 and 4 p.s.i. high.....	8
Radiator hose		Over 4 p.s.i. high.....	34
O.K.....	44	Tire condition, rear	
Leaking.....	8	Practically no wear.....	22 ^a
Loose clamp.....	2	Moderate wear.....	81
Defective hose.....	6	Excessive wear.....	13
Top hose leaking.....	5	Damaged.....	15
Radiator water		Tire pressure, rear	
Level O.K.....	46	O.K. 12 to 16 p.s.i.....	60 ^a
Level low.....	14	1 and 2 p.s.i. low.....	27
Clean.....	35	2 and 3 p.s.i. low.....	11
Dirty, rusty or oily.....	6	Over 4 p.s.i. low.....	13
Rear axle spline		1 and 2 p.s.i. high.....	7
O.K.....	11	2 and 3 p.s.i. high.....	2
Rusty.....	35	Transmission oil level	
Spark		O.K. $\pm \frac{1}{4}$ ".....	39
O.K.....	48	$\frac{1}{4}$ " to $\frac{1}{2}$ " high.....	6
Weak.....	7	Over $\frac{1}{2}$ " high.....	1
Spark plug wires		$\frac{1}{4}$ " to $\frac{1}{2}$ " low.....	3
O.K.....	50	Over $\frac{1}{2}$ " low.....	11
Faulty insulation.....	5	Valve clearances, intake	
Corroded terminals.....	4	O.K. $\pm .002$	101 ^b
Damaged ends.....	1	.002 to .005 too wide.....	40
Spark plug range		Over .005 too wide.....	40
Correct.....	52	.002 to .005 too close.....	17
Too hot.....	2	Over .005 too close.....	12
Too cold.....	1		

^a Number of tires from total of 120.^b Number of valves from total of 210.

<i>Item inspected</i>	<i>Number of tractors</i>	<i>Item inspected</i>	<i>Number of tractors</i>
Valve clearances, exhaust		General tractor condition	
O.K. $\pm .002$	75 ^b	Clean.....	15
.002 to .005 too wide.....	48	Dirty.....	45
Over .005 too wide.....	57	Oily.....	5
.002 to .005 too close.....	16	Estimate of over-all maintenance	
Over .005 too close.....	14	Excellent.....	2
Water pump belt condition		Good.....	25
O.K.....	28	Fair.....	26
Too loose.....	17	Poor.....	7
Too tight.....	5		
Defective.....	14		

^b Number of valves from total of 210.

SUMMARY OF OPERATORS' ANSWERS TO PERSONAL INTERVIEW

The operators' answers were summarized as follows:

A = operators' actual practices

B = operators' answers to quiz on manual recommendations

C = operators' opinions as to frequency of service necessary

Since the tractors inspected were of ten different models, and recommendations differed among models, the information in this summary should be used with discretion.

<i>Item</i>	<i>Number of answers</i>			<i>Item</i>	<i>Number of answers</i>		
	A	B	C		A	B	C
Air cleaner cup check				Air cleaner, type of oil			
2 times daily.....	2	..	1	New.....	53	38	49
Daily.....	9	39	15	Used.....	5	5	5
2 times weekly.....	20	2	16	Same weight as crankcase	52	35	49
Weekly.....	12	1	10	Heavier weight.....	2	3	2
2 weeks.....	6	1	4	Lighter weight.....	6	4	6
Monthly.....	7	1	6	Air cleaner, complete cleaning			
2 to 6 months.....	5	..	3	60 hours.....	2	..	1
At oil change.....	2	1	1	100 hours.....	..	2	..
Often when operating				4 times yearly.....	..	..	1
conditions dusty....	5	1	3	2 times yearly.....	7	4	11
No answer.....	..	16	1	Yearly.....	7	9	21
Air cleaner oil change				2 years.....	6	..	3
When dirt $\frac{1}{4}$ " deep....	6	2	5	4-7 years.....	3	..	1
When dirt $\frac{1}{2}$ " deep....	6	6	7	When needed.....	1	2	1
Daily.....	8	22	11	Never.....	35	2	9
Twice a week.....	9	..	8	No answer.....	..	41	12
Weekly.....	5	3	5	Battery liquid level check			
60 hours.....	8	2	5	Twice a week.....	1	3	4
100 hours.....	13	1	9	Weekly.....	23	16	25
At oil change.....	4	1	3	2 weeks.....	8	..	7
No answer.....	..	23	7	Monthly.....	21	6	19

Item	Number of answers			Item	Number of answers		
	A	B	C		A	B	C
Battery liquid level check—cont.				Crankcase breather service			
2-3 times per year.....	5	..	3	Daily.....	5	6	5
Yearly.....	1	1	1	Twice a week.....	1	..	..
At oil change.....	1	..	1	Weekly.....	9	2	9
No answer.....	..	34	..	Monthly.....	..	3	6
Battery water used				6 months.....	4	1	9
Rain water.....	14	6	13	Yearly.....	10	3	9
Well water.....	33	2	28	2-5 years.....	3	..	1
Distilled water.....	9	24	10	Never.....	17	..	2
Soft water.....	3	..	2	Not required.....	11	4	15
From dehumidifier.....	2	..	2	No answer.....	..	41	4
No answer.....	..	28	5	Crankcase flush			
Belt tension checks				Yes.....	9	14	10
2-3 days.....	4	..	4	No.....	48	19	46
1-2 weeks.....	10	3	9	Occasionally.....	2	..	1
Monthly.....	14	2	12	Once or twice yearly....	2	1	3
3 months.....	3	..	2	Distributor lubrication			
6 months.....	7	..	5	Every 3 days.....	1	..	1
Yearly.....	5	..	6	60 hours.....	4	2	4
When engine gets hot...	5	1	3	120 hours.....	1	..	1
When needed.....	12	2	7	250 hours.....	5	2	8
No answer.....	..	52	12	500 hours.....	8	2	9
Brake adjustment				When points are changed	1	..	..
400 hours.....	2	1	1	None required.....	22	6	7
Yearly.....	12	3	10	With magnetos.....	8	6	6
2-3 years.....	2	1	2	No answer.....	10	42	24
4-6 years.....	4	..	2	Distributor point adjustment			
When needed.....	32	7	24	6 months.....	9	4	9
Never.....	7	..	1	Yearly.....	13	5	13
No answer.....	1	48	20	2 years.....	4	..	3
Carburetor adjustment				When new ones installed	2	..	2
6 months.....	5	..	5	When needed.....	11	..	6
1-3 years.....	1	1	..	Never.....	7	2	1
According to job.....	23	1	15	No answer.....	9	44	21
According to weather...	1	..	..	Engine oil level check			
When needed.....	11	2	8	Twice daily.....	17	7	18
Never.....	15	1	3	Daily.....	35	35	36
No answer.....	4	55	29	Twice weekly.....	3	..	2
Clutch bearing lubrication				Weekly.....	1	..	..
Twice daily.....	..	1	..	Monthly.....	1	..	1
Daily.....	9	7	7	At start of job.....	3	1	2
Twice a week.....	9	2	9	No answer.....	..	17	..
Weekly.....	8	5	10	Engine oil change			
2-4 weeks.....	4	1	3	40 hours.....	5	6	6
6 months.....	4	1	3	50 hours.....	2	1	2
None required.....	15	7	7	60 hours.....	23	17	22
No answer.....	11	36	21	70 hours.....	3	..	3
Clutch adjustment				80-90 hours.....	2	1	1
400 hours.....	3	2	6	100 hours.....	9	4	9
Yearly.....	6	3	7	120 hours.....	7	12	7
2-4 years.....	8	..	5	150 hours.....	2	1	1
When needed.....	25	3	24	200-300 hours.....	3	..	2
Never.....	16	..	3	When oil is dirty.....	2	1	1
No answer.....	2	52	15	No answer.....	2	17	6

Item	Number of answers			Item	Number of answers		
	A	B	C		A	B	C
Engine oil filter change				Fuel sediment bowl service			
Every oil change.....	25	14	24	Daily.....	..	1	..
Every second change....	19	12	18	60 hours.....	3	2	5
Every third change.....	3	1	3	120 hours.....	3	3	5
120-150 hours.....	2	4	2	250 hours.....	3	1	7
2-3 times yearly.....	8	3	7	500 or more.....	14	5	11
Yearly.....	4	..	3	When needed.....	33	1	21
When oil is dirty.....	2	1	1	Never.....	4	..	2
No answer.....	..	25	2	No answer.....	..	47	9
Engine oil consumption				Fuel type used			
None in 60 hours.....	22	..	..	Regular gasoline.....	50	25	39
.5 quart.....	4	..	..	Premium.....	1	1	..
1 quart.....	20	..	..	LP gas.....	5	5	5
2 quart.....	5	..	..	Diesel #1.....	2	2	2
3 quart.....	1	..	..	Diesel #2.....	3	2	2
4 quart.....	4	..	..	No answer.....	..	25	11
Over 4 quarts.....	2	..	..	Fuel storage tank			
Engine oil viscosity (summer)				Overhead tank.....	40	2	15
SAE 10W-30.....	2	..	1	Underground.....	12	2	23
SAE 20-20W.....	20	10	18	1200 gallon.....	1	..	..
SAE 30.....	36	29	35	1000.....	5	1	1
SAE 40.....	2	2	2	500.....	16	1	8
No answer.....	..	19	4	300.....	28	..	9
Engine oil viscosity (winter)				150.....	2	..	..
SAE 10W-30.....	3	..	2	Fuel storage cap			
SAE 20W-40.....	..	1	..	Weighted.....	17	2	19
SAE 10-10W.....	17	21	17	Open vent.....	25	1	17
SAE 20-20W.....	29	17	28	Pressure vacuum.....	5	1	5
SAE 30.....	11	2	10	Front wheel lubrication			
No answer.....	..	19	3	Daily.....	1	1	1
Engine oil, API class				Weekly.....	..	1	..
ML—regular.....	1	3	1	Monthly.....	2	1	2
MM—premium.....	5	..	3	6 months.....	7	13	9
MS.....	20	3	17	Yearly.....	28	19	31
DG } S ¹	22	1	16	2 years.....	11	..	9
DS } S ²	3	2	3	3 years or longer.....	4	..	2
No answer.....	9	51	20	Never.....	7	..	1
Engine timing				No answer.....	..	25	5
6 months.....	2	1	2	Front wheel, type of lube			
Yearly.....	8	4	9	Transmission oil.....	6	4	5
2 years.....	3	..	2	Gun grease.....	50	27	47
At overhaul.....	3	..	3	Fiber grease.....	2	2	2
When needed.....	14	3	11	No answer.....	2	27	6
Never.....	21	6	11	Generator lubrication			
No answer.....	4	41	17	Twice daily.....	1	1	1
Engine tuneup				Daily.....	4	3	4
Every 6 months.....	6	1	6	Every other day.....	1	1	1
Yearly.....	32	9	26	60 hours.....	19	14	19
2 years.....	7	..	3	120 hours.....	15	8	17
At major overhaul.....	4	..	1	250 hours.....	11	1	10
When needed.....	12	..	7	3 months.....	2	1	2
By dealer's mechanic....	24	14	23	Yearly.....	2	..	2
By other mechanic.....	5	..	2	No answer.....	5	31	4
By owner.....	3	1	1				

Item	Number of answers			Item	Number of answers		
	A	B	C		A	B	C
Governor adjustment				Radiator flush			
6 months.....	1	..	1	Twice a year.....	15	8	14
Yearly.....	4	1	7	Yearly.....	26	14	30
2 years.....	..	3	..	2 years or more.....	5	..	1
When gives trouble.....	2	..	2	Never.....	13	..	3
When needed.....	14	5	11	No answer.....	1	38	12
According to load.....	2	..	2	Spark plug inspection			
Never.....	35	..	17	100 hours.....	1	3	4
No answer.....	2	51	20	200 hours.....	12	4	17
Grease fittings, rear axle				500 hours.....	3	1	3
Twice daily.....	1	2	1	2-3 times a year.....	8	4	11
Daily.....	21	17	19	Yearly.....	6	1	3
Twice weekly.....	10	1	11	When engine misses.....	18	1	5
Weekly.....	9	6	9	Never.....	10	4	4
Monthly.....	1	..	1	No answer.....	..	37	8
6 months.....	3	1	3	Spark plugs, replaced			
Infrequently.....	10	7	8	250 hours.....	6	2	8
No answer.....	5	26	8	500 hours.....	13	5	16
Grease fittings, steering				Yearly.....	10	2	7
Twice daily.....	4	4	3	2-3 years.....	11	..	7
Daily.....	28	26	28	When needed.....	14	..	8
Twice a week.....	10	1	12	Not replaced.....	4	3	3
Weekly.....	12	4	10	No answer.....	..	43	6
Monthly.....	2	1	2	Starter lubrication			
6 months.....	3	..	2	Daily.....	2	1	2
Infrequently.....	1	..	1	2-3 days.....	2	1	2
No answer.....	..	24	2	60 hours.....	5	3	6
Hydraulic system, level check				120 hours.....	9	5	8
Daily.....	12	12	12	250 hours.....	5	..	5
Twice weekly.....	4	1	4	2-3 times yearly.....	3	..	2
60-120 hours.....	11	4	11	Yearly.....	2	..	2
1-4 times a year.....	10	..	6	None required.....	30	18	21
Before using.....	8	..	8	No answer.....	2	32	12
No answer.....	15	43	19	Steering gear oil level check			
Hydraulic system oil change				Monthly.....	1	1	1
1-4 months.....	1	2	3	6 months.....	6	7	7
3-6 months.....	1	6	4	Yearly.....	27	12	28
1-2 years.....	17	10	14	At overhaul.....	7	..	4
Never.....	30	..	11	Never.....	16	..	3
No answer.....	11	42	28	No answer.....	3	40	17
Hydraulic system oil type				Steering gear oil change			
SAE 10.....	10	5	9	6 months.....	..	..	1
SAE 20.....	17	13	15	Yearly.....	1	3	1
SAE 30.....	9	5	8	Never.....	43	6	36
Special hydraulic.....	10	6	6	No answer.....	16	51	22
No answer.....	14	31	22	Tire pressure check			
Hydraulic system flush				Twice weekly.....	..	..	1
Yes.....	4	7	9	Weekly.....	2	6	6
No.....	40	13	30	2 weeks.....	2	..	2
No answer.....	16	40	21	1-2 months.....	7	5	6
Radiator level check				2-3 times yearly.....	6	..	4
Daily.....	7	4	6	Yearly.....	3	1	2
Twice weekly.....	32	30	32	When looks low.....	40	..	23
Weekly.....	6	1	7	According to job.....	1	..	1
Monthly.....	10	..	12	No answer.....	..	48	15
When it gets hot.....	6	..	3				
No answer.....	..	25	..				

Item	Number of answers			Item	Number of answers		
	A	B	C		A	B	C
Transmission oil level check				Transmission oil type (winter)—cont.			
Daily.....	1	1	1	SAE 140.....	13	5	8
Weekly.....	1	2	1	Add fuel oil.....	..	2	..
Monthly.....	8	8	7	No answer.....	20	34	24
2-3 times yearly.....	22	9	26	Transmission flush			
Yearly.....	24	8	22	Yes.....	11	18	20
2 years.....	3	..	1	No.....	30	10	25
No answer.....	1	32	2	No answer.....	19	32	15
Transmission oil change				Valve clearance check			
6 months.....	2	11	1	200 hours.....	3	3	7
Yearly.....	5	18	14	500 hours.....	10	7	16
2 years.....	3	4	4	Yearly.....	9	4	8
3-4 years.....	4	..	4	2 years.....	4	..	2
5-6 years.....	3	1	2	At overhaul.....	6	..	2
At overhaul.....	3	..	1	When valves noisy.....	6	..	3
Never.....	39	3	18	Never.....	18	2	2
No answer.....	1	23	16	No answer.....	4	44	20
Transmission oil type (summer)				Water pump lubrication			
SAE 80.....	4	2	5	Daily.....	9	8	8
SAE 90.....	21	14	20	Every 2 days.....	3	..	3
SAE 140.....	16	13	12	Weekly.....	9	4	10
Special hydraulic.....	2	..	..	Monthly.....	1	1	1
No answer.....	17	31	23	Every 4 months.....	3	..	3
Transmission oil type (winter)				Not required.....	21	14	14
SAE 80.....	4	3	6	No answer.....	14	33	21
SAE 90.....	23	16	22				

LITERATURE CITED

1. GATES, V. A., BERGSTROM, R. F., and WENDT, L. A. Further discussion on "oil spot" evaluation of used engine lubricants. Paper presented at Soc. Automotive Engin. National West Coast meeting, 1955 (preprint No. 572).
2. ILLINOIS AGRICULTURAL EXPERIMENT STATION. Progress in solving farm problems in Illinois. Ill. Agr. Exp. Sta. Nine-Year Rpt. (1938-1947):154-158. 1948.
3. NAVARIN, R. C., and USOW, K. Design and ease of maintenance. Paper presented at Soc. Automotive Engin. Tractor meeting, 1955 (preprint No. 580).
4. SHAWL, R. I. Tractor repair and maintenance. Ill. Agr. Col. Ext. Cir. 589:4. 1945.
5. SMITH, C. W., and LARSEN, L. F. Factors affecting the efficiency of farm tractors. Paper presented at Soc. Automotive Engin. Tractor meeting, 1952 (preprint No. 805).
6. WEBER, J. A. Valve life study of sixty farm tractors. Paper presented at Soc. Automotive Engin. Tractor meeting, 1955 (preprint No. 587).

UNIVERSITY OF ILLINOIS-URBANA



3 0112 018403615